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### Determination of Distal Fusion Level with Segmental Pedicle Screw Fixation in Single Thoracic Idiopathic Scoliosis

Se-Il Suk, M.D., Jin-Hyok Kim, M.D., Sang-Min Lee, M.D., Ewy-Ryong Chung, M.D.,  
Ki-Ho Nah\* M.D., Jung-Hee Lee, M.D., Sung-Soo Kim, M.D.,  
Soo-Chul Park, M.D., Rack-Yong Chung, M.D., Sung-Wook Won, M.D.

*Seoul Spine Institute, Inje University Sanggye Paik Hospital*

*Dept. of Orthopaedic Surgery, St. Paul 's Hospital. Catholic University of Korea School of Medicine\**

#### – Abstract –

**Study Design :** Retrospective study.

**Objectives :** To determine the exact distal fusion level in the treatment of single thoracic idiopathic scoliosis (King III and IV) with segmental pedicle screw fixation and rod rotation.

**Summary of Literature Review :** Pedicle screw fixation effectively shortens the distal fusion extent by improved 3-D deformity correction. However, the selection of distal fusion extent remains controversial in single thoracic idiopathic scoliosis.

**Material and Methods :** Forty-two single thoracic adolescent idiopathic scoliosis patients subject to segmental pedicle screw fixation and rod rotation with minimum follow-up of 2 years (2 ~ 6 years) were analyzed. The patients were grouped according to the distal fusion level with reference to the standing neutral vertebra (NV) for comparison of deformity correction, radiological and clinical spinal balance using standing radiographs. Distal fusion down to NV +1 was in 9 patients, NV in 5, NV-1 in 9, NV-2 in 12 and NV-3 in 7 patients respectively.

**Results :** Preoperative  $50 \pm 11^\circ$  of thoracic deformity was corrected to  $13 \pm 5^\circ$  showing 74% of curve correction. Preoperative  $23 \pm 7^\circ$  of lumbar deformity was corrected to  $2 \pm 8^\circ$  showing 93% of curve correction. Postoperative adding on deformity was obtained in 14 patients. Significant difference was found not by King classification but by distal fusion level: significantly higher chance of unsatisfactory results from not going to the NV-1 ( $p=0.001$ ).

**Conclusions :** In correction of single thoracic idiopathic scoliosis with segmental pedicle screw fixation, the curve should be fused to NV-1 saving one or more motion segments when compared to the fusion to the stable vertebra.

**Key Words :** Adolescent idiopathic scoliosis, Single thoracic curve, Distal fusion level, Pedicle screw fixation, Rod rotation

Address reprint requests to

**Ewy-Ryong Chung, M.D.**

Seoul Spine Institute, Inje University Sanggye Paik Hosital

761-1 Sanggye Dong, Nowon-Ku, Seoul 139-707, Korea

Tel : 82-2-950-1290, Fax : 82-2-3392-1101, E-mail : dragon@sanggyepaik.ac.kr

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11 ,  
31 , 15.5 (10.1 19.6 ) .

가 (neutral vertebra, NV)  
1,3,4,7,8) 가  
Cobb  
13) 가 가  
7  
가 (adding on phenomenon) (gluteal cleft) 가  
가 가  
가 2 cm  
42 가  
NV+1,  
NV,  
NV-1,  
(hook) 15) 3,10,11,16) 가  
가 King NV-3 NV-2, NV+1 9 , NV  
2 5 , NV-1 9 , NV-2 12 , NV-3 7 .  
1,2,9) 50 ± 11 ° ; 40  
King 3 85 ° 63% .  
24 ± 7 ° ; 12~49 ° ,  
117% .  
6). King 4  
4 가  
6). King 3  
4  
Harrington 가  
6).  
1.  
King 3 4  
42 50 ± 11 °  
13 ± 5 ° (2~23 °) 74% (48~96%)  
, King 3 32 48 ± 8 °  
12 ± 5 ° 75% ,  
King 4 10 59 ± 14 °  
16 ± 4 ° 72% (Table  
1).  
NV+1  
51 ° 12 ° (77%) , NV  
44 ° 12 ° (74%) ,  
NV-1 55 ° 16 °  
71%) , NV-2 52 °  
13 ° (74%) , NV-3 45 °  
12 ° (74%) .  
King  
가 (p>0.05).

(King 3 4 )  
13)  
2 가 가 42 (King  
3 32 , King 4 10 )  
. King 2  
가 가

**Table 1.** Preoperative and postoperative curve characteristics.

	Type III	Type IV	Total
No. of Patients	32	10	42
Thoracic			
Preoperative Curves	47.7 ± 7.9° (40~67)	58.8 ± 13.6° (41~85)	50.3 ± 10.5° (40~85)
Postoperative Curves	12.1 ± 5.3° (2~23)	16.2 ± 4.4° (8~22)	13.0 ± 5.3° (2~23)
Correction Rate	74.7 ± 10.2% (47.7~95.6)	71.7 ± 8.4% (53.7~86.9)	74.0 ± 9.8% (47.7~95.6)
Lumbar			
Preoperative Curves	22.7 ± 7.2° (12~49)	25.4 ± 6.5° (15~35)	23.4 ± 7.0° (12~49)
Postop. Curves	2.5 ± 7.8° (-12~17)	2.1 ± 7.6° (-12~14)	2.4 ± 7.7° (-12~17)
Correction Rate	93.1 ± 35.6% (47.4~180.0)	94.2 ± 31.0% (53.3~157.1)	93.4 ± 34.2% (47.4~180.0)
Postoperative spinal balance	27/32	8/10	35/42
Postoperative lumbar adding on deformity	9/32	5/10	14/42

**Table 2.** Comparison between satisfactory and unsatisfactory results.

	Satisfactory	Unsatisfactory
Type III	23/32 (72%)	9/32 (28%)
Type IV	5/10 (50%)	5/10 (50%)
NV-EV*	1.7 ± 1.6	3.3 ± 0.9
DF	13.0 ± 1.1	13.3 ± 1.1
DF-NV*	-0.4 ± 1.3	-2.4 ± 0.5
DF-EV	1.3 ± 0.6	0.9 ± 1.0
DF-SV	-1.9 ± 1.3	-2.6 ± 0.8
Thoracic Curve		
Preoperative	50.6 ± 9.4°	49.6 ± 12.9°
Flexibility	64.4 ± 8.0%	61.3 ± 9.0%
Postoperative	12.7 ± 5.5°	12.8 ± 5.0°
Correction Rate	75.2 ± 9.4%	71.6 ± 10.5%
Lumbar Curve		
Preoperative	24.6 ± 7.0°	20.9 ± 6.7°
Flexibility	115.5 ± 17.3%	120.8 ± 27.4%
Postoperative*	4.9 ± 5.5°	-2.6 ± 9.0°
Correction Rate*	80.4 ± 20.4%	119.4 ± 41.6%

NV : neutal vertebrae

EV : end vertebra

DF : distal fusion level. L1 was counted as 13, and L2 was 14, and so on.

SV : stable vertebra

Flexibility (%) = (preoperative angle-bending angle / preoperative angle) × 100

\* p&lt;0.01 in Mann-Whitney test.

**Table 3.** Postoperative adding on according to the relationships between the neutral vertebra (NV) and end vertebra (EV)

NV - EV	DF-NV					Total
	1	0	-1	-2	-3	
0	0 / 9 (0%)					0 / 9 ( 0%)
1		0 / 5 (0%)				0 / 5 ( 0%)
2			0 / 6 (0%)	3 / 3 (100%)		3 / 9 (33%)
3			0 / 2 (0%)	2 / 3 ( 67%)	3 / 3 (100%)	5 / 8 (63%)
4			0 / 1 (0%)	3 / 4 ( 75%)	2 / 4 ( 50%)	5 / 9 (56%)
5				1 / 2 ( 50%)		1 / 2 (50%)
Total	0 / 9 (0%)	0 / 5 (0%)	0 / 9 (0%)	9 /12 ( 75%)	5 / 7 ( 71%)	14 / 42 (33%)

NV : neutal vertebrae

EV : end vertebra

DF : distal fusion level

\* Significant difference of postoperative spinal imbalance and adding on between fusion below NV-1 groups (NV+1, NV and NV-1) and above NV-1 groups (NV-2, NV-3) (p<0.01).

2. 가 1 (p=0.001, Table

가 3, Fig. 3).

가 , adding on deformity)

King 3 32  
9 (28%), King 4 10 5 (50%) 14  
(Table1). 14 가

, 7 2 cm

King 3 4 16)

(p>0.05, Mann-Whitney test),

가 (Table 2).

2.2 , 1.1 , 가

. 42 (stable vertebra)  
가 (stable zone)

9 , 3 1 5 , 2 6).  
8 , 4 11 가 King 3 4 가  
(Table 3). 가

1 , King 6) Harrington  
(NV) 1 (NV+1)

(Table 3, Fig. 1). 가 3 가

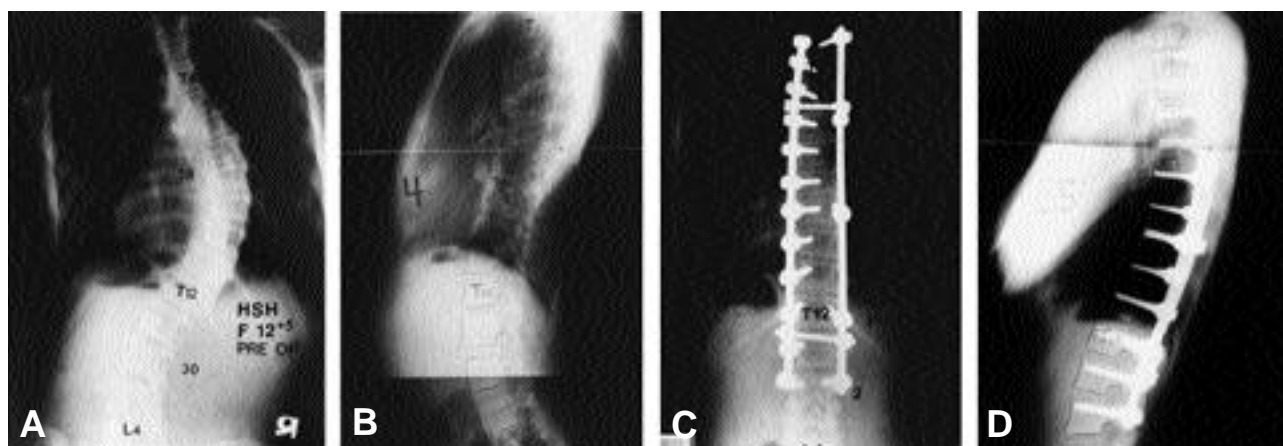
2 , 1 가 . Har-  
(NV-1) rington 2  
(Table 3, Fig. 2),

2 3 가 5),  
가 . 3 가

2 (NV-2) 9 (9/12, ,  
75%) , 3 (NV-3) 5 (5/7, 71%) 3 가

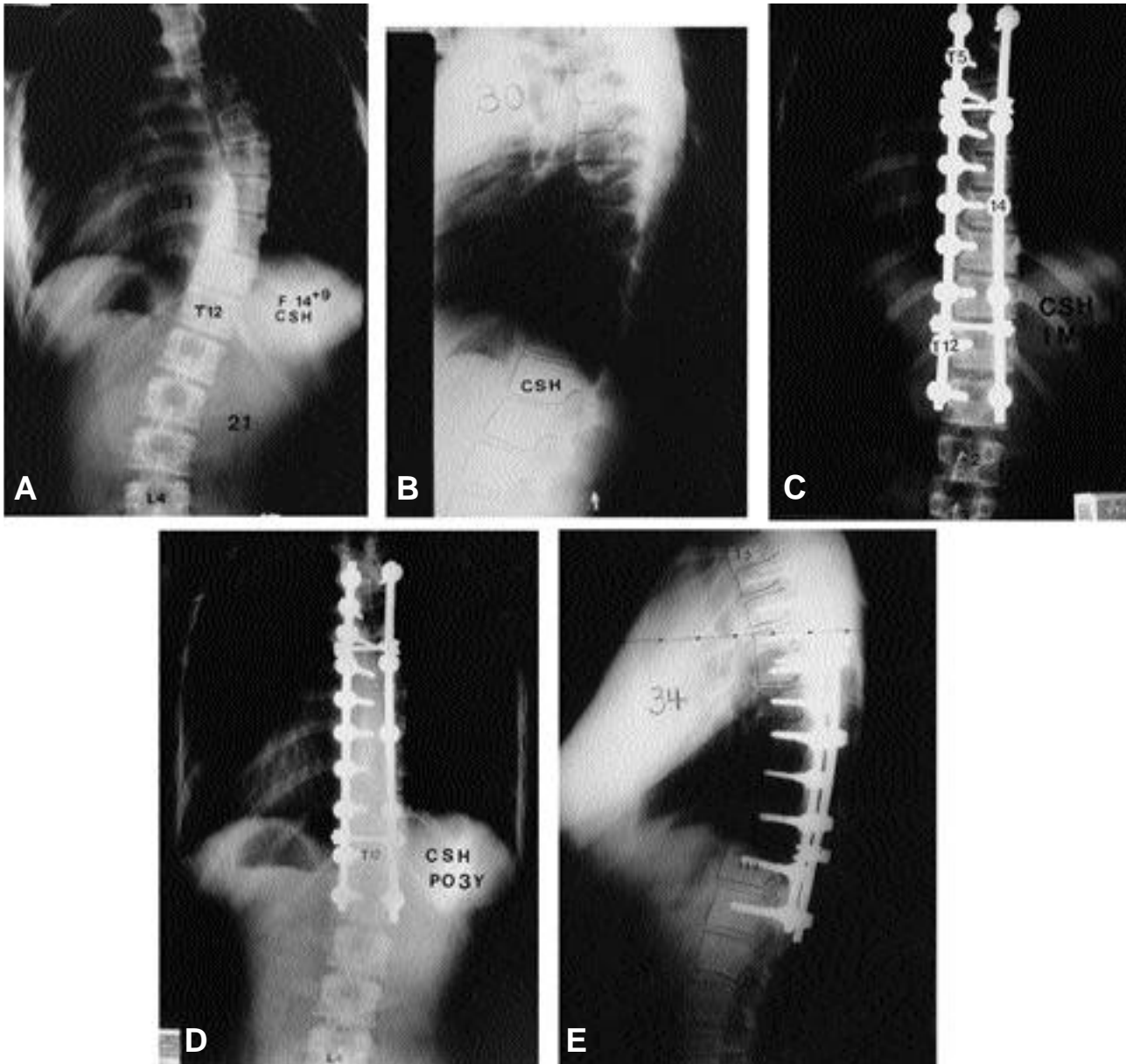


**Fig. 1-A.** Preoperative standing anteroposterior radiograph of a 15.8 year old female with 50° thoracic and 32° lumbar fractional curve. As determined by the spinous process and pedicle shadows, the neutral vertebrae was L1.  
**B.** Preoperative standing lateral radiograph.  
**C.** Anteroposterior radiograph taken 3.5 years after surgery. The distal fusion was down to neutral vertebra(NV). The thoracic curve is corrected to 10° with 9° lumbar fractional curve and balanced spine.  
**D.** Lateral radiograph taken 3.5 years after surgery.



**Fig. 2-A.** Preoperative standing anteroposterior radiograph of a 12.4 year old female with 58° thoracic and 30° lumbar fractional curve. As determined by the spinous process and pedicle shadows, the neutral vertebrae was L3.  
**B.** Preoperative standing lateral radiograph. The thoracic spine was hypokyphotic, 4° of kyphosis.  
**C.** Anteroposterior radiograph taken 4 years after surgery. The distal fusion was down to NV-1 (one level proximal to neutral vertebra). The thoracic curve is corrected to 3° with 29° lumbar fractional curve and balanced spine.  
**D.** Lateral radiograph taken 4 years after surgery. The thoracic kyphosis was improved to 25°.

가 , King 3 4  
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 , (Hook)가  
 , (Table 2). ,  
 가 , 가  
 가 가



**Fig. 3-A.** Preoperative standing anteroposterior radiograph of a 14.8 year old female with 51° thoracic and 21° lumbar fractional curve. As determined by the spinous process and pedicle shadows, the neutral vertebrae was L3.  
**B.** Preoperative standing lateral radiograph.  
**C.** Anteroposterior radiograph taken 2 weeks after surgery. The distal fusion was down to NV-2 (two level proximal to neutral vertebra). The thoracic curve was corrected to 14° with 2° lumbar fractional curve and balanced spine.  
**D.** Anteroposterior radiograph taken 3 years after surgery. The lumbar fractional curve shows reversal, resulting in extension of the index thoracic curve into the lumbar segments through adding on.  
**E.** Lateral radiograph taken 3 years after surgery.

King 2

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